

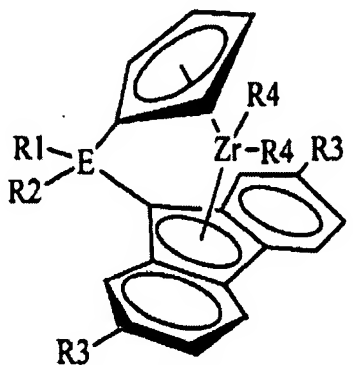
AMMENDMENTS TO THE CLAIMS

The following listing of the claims is provided in accordance with 37 C.F.R. §1.121.

1-22. (canceled)

23. (currently amended) A catalyst composition consisting essentially of the contact product of at least one metallocene compound and at least one chemically-treated solid oxide, wherein:

a) the at least one metallocene compound is selected from a compound of the formula:



wherein E is selected from C, Si, Ge, or Sn; R1 is selected from H or a hydrocarbyl group having from 1 to about 20 carbon atoms; R2 is selected from an alkenyl group having from about 3 to about 12 carbon atoms; and R3 is selected from H or a hydrocarbyl group having from 1 to about 12 carbon atoms; and R4 is selected from H or a hydrocarbyl group having from 1 to about 20 carbon atoms ~~has the following formula:~~

~~_____ $(X^1)(X^2)(X^3)(X^4)M^1$;~~

~~_____ wherein M^1 is selected from titanium, zirconium, hafnium, vanadium, niobium, tantalum, chromium, molybdenum, or tungsten;~~

~~_____ (X^1) is selected from a Group I ligand,~~

~~_____ wherein the Group I ligand is selected from a cyclopentadienyl, an indenyl, a fluorenyl, a substituted cyclopentadienyl, a substituted indenyl, or a substituted fluorenyl;~~

~~_____ wherein each substituent on the substituted cyclopentadienyl, substituted indenyl, or substituted fluorenyl (X^1) is independently selected from an aliphatic group, an aromatic group, a cyclic group, a combination of aliphatic and cyclic groups, an oxygen group, a sulfur group, a nitrogen group, a phosphorus group, an arsenic group, a carbon group, a silicon group, a germanium group, a tin group, a lead group, a boron group, an aluminum group, SO_2X , $OAlX_2$, $OSiX_3$, OPX_2 , SX , OSO_2X , AsX_2 , $As(O)X_2$, or PX_2 , wherein X is selected independently from halide, H, NH_2 , OR, or SR, wherein R is a hydrocarbyl, or a substituted derivative thereof, having from 1 to about 20 carbon atoms; a halide; or hydrogen;~~

~~_____ (X^3) is selected from an aliphatic group, an aromatic group, a cyclic group, a combination of aliphatic and cyclic groups, or a substituted derivative thereof, having from 1 to about 20 carbon atoms;~~

~~_____ (X^4) is independently selected from a Group II ligand,~~

~~_____ wherein the Group II ligand is selected from an aliphatic group, an aromatic group, a cyclic group, a combination of aliphatic and cyclic groups, an oxygen group, a sulfur group, a nitrogen group, a phosphorus group, an arsenic group, a carbon group, a~~

~~silicon group, a germanium group, a tin group, a lead group, a boron group, an aluminum group, SO_2X , OAlX_2 , OSiX_3 , OPX_2 , SX , OSO_2X , AsX_2 , As(O)X_2 , or PX_2 , wherein X is selected independently from halide, H, NH_2 , OR, or SR, wherein R is a hydrocarbyl, or a substituted derivative thereof, having from 1 to about 20 carbon atoms; a halide;~~

~~——— (X^2) is independently selected from a Group I or a Group II ligand;~~

~~——— wherein (X^1) and (X^2) are optionally connected by a bridging group, wherein the length of the bridging group between (X^1) and (X^2) is one, two, or three atoms; the one, two, or one, two, or three atoms of the bridging group are independently selected from C, Si, Ge, or Sn; the bridging group is saturated or unsaturated; and the bridging group is substituted or unsubstituted; and~~

~~——— wherein any substituent on the bridging group is independently selected from an alkenyl group, an alkynyl group, an alkadienyl group, an aliphatic group, an aromatic group, a cyclic group, a combination of aliphatic and cyclic groups, an oxygen group, a sulfur group, a nitrogen group, a phosphorus group, an arsenic group, a carbon group, a silicon group, a germanium group, a tin group, a lead group, a boron group, an aluminum group, SO_2X , OAlX_2 , OSiX_3 , OPX_2 , SX , OSO_2X , AsX_2 , As(O)X_2 , or PX_2 , wherein X is selected independently from halide, H, NH_2 , OR, or SR, wherein R is a hydrocarbyl, or a substituted derivative thereof, having from 1 to about 20 carbon atoms; a halide; or hydrogen; and~~

b) the at least one chemically-treated solid oxide comprises a solid oxide treated with an electron-withdrawing anion;

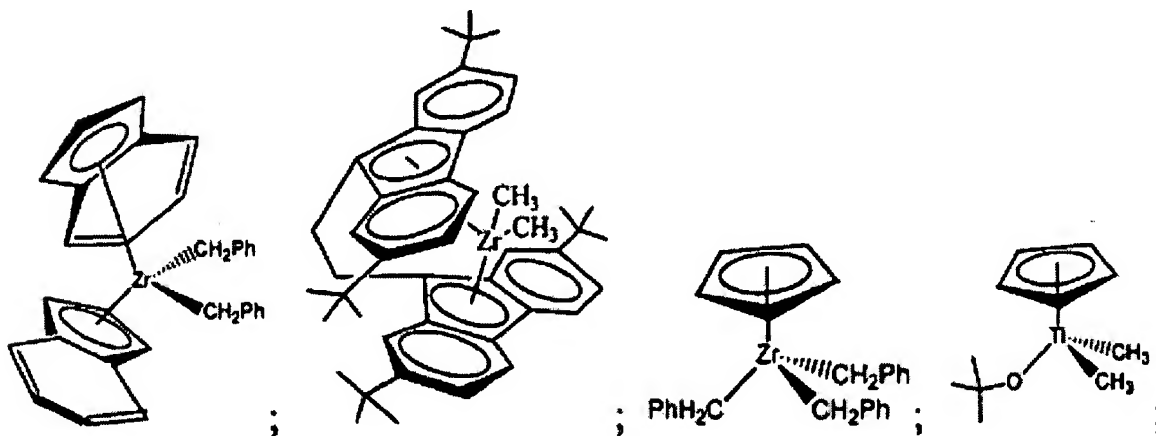
wherein the solid oxide is selected from silica, alumina, silica-alumina, silica-zirconia, alumina-zirconia, aluminum phosphate, heteropolytungstates, titania, magnesia, boria, zinc oxide, mixed oxides thereof, or mixtures thereof; and

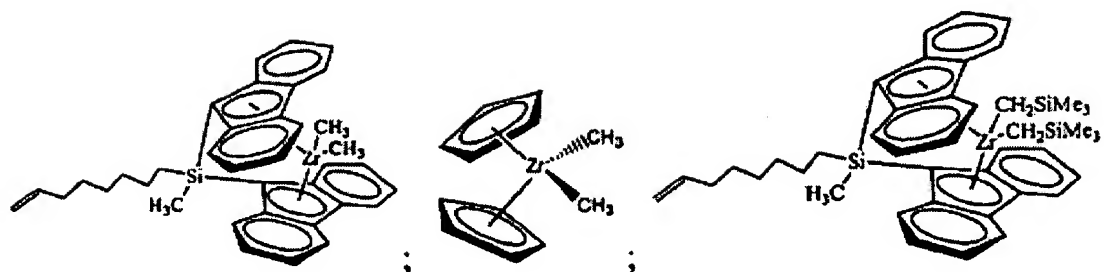
the electron-withdrawing anion is selected from fluoride, chloride, bromide, phosphate, triflate, bisulfate, sulfate, or any combination thereof.

24. (canceled)

25. (currently amended) ~~The catalyst composition of Claim 23, wherein~~ A catalyst composition consisting essentially of the contact product of at least one metallocene compound and at least one chemically-treated solid oxide, wherein:

a) the at least one metallocene compound is selected from:





or any combination thereof[.]; and

b) the at least one chemically-treated solid oxide comprises a solid oxide treated with an electron-withdrawing anion;

wherein the solid oxide is selected from silica, alumina, silica-alumina, silica-zirconia, alumina-zirconia, aluminum phosphate, heteropolytungstates, titania, magnesia, boria, zinc oxide, mixed oxides thereof, or mixtures thereof; and

the electron-withdrawing anion is selected from fluoride, chloride, bromide, phosphate, triflate, bisulfate, sulfate, or any combination thereof.

26. (currently amended) The catalyst composition of Claim 23, wherein A catalyst composition consisting essentially of the contact product of at least one metallocene compound and at least one chemically-treated solid oxide, wherein:

a) the at least one metallocene compound is selected from:

bis(cyclopentadienyl)hafnium dimethyl;

bis(cyclopentadienyl)zirconium dibenzyl;

1,2-ethanediylbis(η^5 -1-indenyl) dimethylhafnium;

1,2-ethanediylbis(η^5 -1-indenyl)dimethylzirconium;

3,3-pentanediylobis(η^5 -4,5,6,7-tetrahydro-1-indenyl)hafnium dimethyl;
methylphenylsilylbis(η^5 -4,5,6,7-tetrahydro-1-indenyl)zirconium dimethyl;
bis(1-*n*-butyl-3-methyl-cyclopentadienyl) zirconium dimethyl;
bis(*n*-butylcyclopentadienyl)zirconium dimethyl;
dimethylsilylbis(1-indenyl)zirconium bis(trimethylsilylmethyl);
octyl(phenyl)silylbis(1-indenyl)hafnium dimethyl;
dimethylsilylbis(η^5 -4,5,6,7-tetrahydro-1-indenyl)zirconium dimethyl;
dimethylsilylbis(2-methyl-1-indenyl)zirconium dibenzyl;
1,2-ethanediylbis(9-fluorenyl)zirconium dimethyl;
(indenyl)trisbenzyl titanium(IV);
(isopropylamidodimethylsilyl)cyclopentadienyltitanium dibenzyl;
bis(pentamethylcyclopentadienyl)zirconium dimethyl;
bis(indenyl) zirconium dimethyl;
methyl(octyl)silylbis(9-fluorenyl)zirconium dimethyl;
bis(2,7-di-*tert*-butylfluorenyl)-ethan-1,2-diyl)zirconium(IV) dimethyl;
or any combination thereof[.]; and

b) the at least one chemically-treated solid oxide comprises a solid oxide treated with an electron-withdrawing anion;

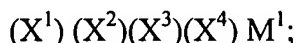
wherein the solid oxide is selected from silica, alumina, silica-alumina, silica-zirconia, alumina-zirconia, aluminum phosphate, heteropolytungstates, titania, magnesia, boria, zinc oxide, mixed oxides thereof, or mixtures thereof; and

the electron-withdrawing anion is selected from fluoride, chloride, bromide,

phosphate, triflate, bisulfate, sulfate, or any combination thereof.

27. (currently amended) A catalyst composition consisting essentially of the contact product of a metallocene compound and a chemically-treated solid oxide, wherein:

a) the metallocene compound has the following formula:



wherein M^1 is selected from titanium, zirconium, hafnium, or vanadium;

(X^1) is selected from a cyclopentadienyl, an indenyl, a fluorenyl, a substituted cyclopentadienyl, a substituted indenyl, or a substituted fluorenyl;

wherein each substituent on the substituted cyclopentadienyl, substituted indenyl, or substituted fluorenyl (X^1) is independently selected from an aliphatic group, an aromatic group, a cyclic group, a combination of aliphatic and cyclic groups, an oxygen group, a sulfur group, a nitrogen group, a phosphorus group, an arsenic group, a carbon group, a silicon group, a germanium group, a tin group, a lead group, a boron group, an aluminum group, $-SO_2X$, $-OAlX_2$, $-OSiX_3$, $-OPX_2$, $-SX$, $-OSO_2X$, $-AsX_2$, $-As(O)X_2$, or $-PX_2$, wherein X is selected independently from halide, H, NH_2 , OR, or SR, wherein R is a hydrocarbyl, or a substituted derivative thereof, having from 1 to about 20 carbon atoms; a halide; or hydrogen; and

(X^2) , (X^3) , and (X^4) are independently ~~seleeed~~ selected from a hydrocarbyl group or a substituted hydrocarbyl group, having from 1 to about 20 carbon atoms; and

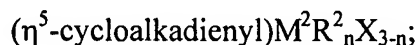
b) the chemically-treated solid oxide comprises a solid oxide treated with an electron-withdrawing anion;

wherein the solid oxide is selected from silica, alumina, silica-alumina, silica-zirconia, alumina-zirconia, aluminum phosphate, heteropolytungstates, titania, magnesia, boria, zinc oxide, mixed oxides thereof, or mixtures thereof; and

the electron-withdrawing anion is selected from fluoride, chloride, bromide, phosphate, triflate, bisulfate, sulfate, or any combination thereof.

28. (previously presented) A catalyst composition consisting essentially of the contact product of a metallocene compound and a chemically-treated solid oxide, wherein:

a) the metallocene compound has the following formula:



wherein cycloalkadienyl is selected from cyclopentadienyl, indenyl, fluorenyl, or substituted analogs thereof;

M^2 is selected from Ti, Zr, or Hf;

R^2 is independently selected from substituted or non-substituted alkyl, cycloalkyl, aryl, aralkyl, having from 1 to about 20 carbon atoms;

X is independently selected from F; Cl; Br; I; or substituted or non-substituted alkyl, cycloalkyl, aryl, aralkyl, alkoxide, or aryloxy having from 1 to about 20 carbon atoms; and

n is an integer from 1 to 3 inclusive; and

b) the chemically-treated solid oxide comprises a solid oxide treated with an electron-withdrawing anion;

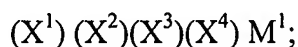
wherein the solid oxide is selected from silica, alumina, silica-alumina, silica-zirconia, alumina-zirconia, aluminum phosphate, heteropolytungstates, titania, magnesia, boria, zinc oxide, mixed oxides thereof, or mixtures thereof; and

the electron-withdrawing anion is selected from fluoride, chloride, bromide, phosphate, triflate, bisulfate, sulfate, or any combination thereof.

29. (canceled)

30. (previously presented) A process to produce a catalyst composition comprising contacting a metallocene compound and a chemically-treated solid oxide, wherein:

a) the metallocene compound has the following formula:



wherein M^1 is selected from titanium, zirconium, hafnium, vanadium, niobium, tantalum, chromium, molybdenum, or tungsten;

(X^1) is selected from a Group-I ligand,

wherein the Group-I ligand is selected from a cyclopentadienyl, an indenyl, a fluorenyl, a substituted cyclopentadienyl, a substituted indenyl, or a substituted fluorenyl;

wherein each substituent on the substituted cyclopentadienyl, substituted indenyl, or substituted fluorenyl (X^1) is independently selected from an aliphatic group, an aromatic group, a cyclic group, a combination of aliphatic and cyclic groups, an oxygen group, a sulfur group, a nitrogen group, a phosphorus group, an arsenic group, a carbon group, a silicon group, a germanium group, a tin group, a lead group, a boron group, an

aluminum group, $-\text{SO}_2\text{X}$, $-\text{OAlX}_2$, $-\text{OSiX}_3$, $-\text{OPX}_2$, $-\text{SX}$, $-\text{OSO}_2\text{X}$, $-\text{AsX}_2$, $-\text{As}(\text{O})\text{X}_2$, or $-\text{PX}_2$, wherein X is selected independently from halide, H, NH_2 , OR, or SR, wherein R is a hydrocarbyl, or a substituted derivative thereof, having from 1 to about 20 carbon atoms; a halide; or hydrogen;

(X^3) is selected from an aliphatic group, an aromatic group, a cyclic group, a combination of aliphatic and cyclic groups, or a substituted derivative thereof, having from 1 to about 20 carbon atoms;

(X^4) is independently selected from a Group-II ligand,

wherein the Group-II ligand is selected from an aliphatic group, an aromatic group, a cyclic group, a combination of aliphatic and cyclic groups, an oxygen group, a sulfur group, a nitrogen group, a phosphorus group, an arsenic group, a carbon group, a silicon group, a germanium group, a tin group, a lead group, a boron group, an aluminum group, $-\text{SO}_2\text{X}$, $-\text{OAlX}_2$, $-\text{OSiX}_3$, $-\text{OPX}_2$, $-\text{SX}$, $-\text{OSO}_2\text{X}$, $-\text{AsX}_2$, $-\text{As}(\text{O})\text{X}_2$, or $-\text{PX}_2$, wherein X is selected independently from halide, H, NH_2 , OR, or SR, wherein R is a hydrocarbyl, or a substituted derivative thereof, having from 1 to about 20 carbon atoms; a halide;

(X^2) is independently selected from a Group-I or a Group-II ligand;

wherein (X^1) and (X^2) are optionally connected by a bridging group, wherein the length of the bridging group between (X^1) and (X^2) is one, two, or three atoms; the one, two, or one, two, or three atoms of the bridging group are independently selected from C, Si, Ge, or Sn; the bridging group is saturated or unsaturated; and the bridging group is substituted or unsubstituted; and

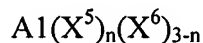
wherein any substituent on the bridging group is independently selected from an alkenyl group, an alkynyl group, an alkadienyl group, an aliphatic group, an aromatic group, a cyclic group, a combination of aliphatic and cyclic groups, an oxygen group, a sulfur group, a nitrogen group, a phosphorus group, an arsenic group, a carbon group, a silicon group, a germanium group, a tin group, a lead group, a boron group, an aluminum group, $-\text{SO}_2\text{X}$, $-\text{OAlX}_2$, $-\text{OSiX}_3$, $-\text{OPX}_2$, $-\text{SX}$, $-\text{OSO}_2\text{X}$, $-\text{AsX}_2$, $-\text{As}(\text{O})\text{X}_2$, or $-\text{PX}_2$, wherein X is selected independently from halide, H, NH_2 , OR, or SR, wherein R is a hydrocarbyl, or a substituted derivative thereof, having from 1 to about 20 carbon atoms; a halide; or hydrogen; and

b) the chemically-treated solid oxide comprises a solid oxide treated with an electron-withdrawing anion;

wherein the solid oxide is selected from silica, alumina, silica-alumina, silica-zirconia, alumina-zirconia, aluminum phosphate, heteropolytungstates, titania, magnesia, boria, zinc oxide, mixed oxides thereof, or mixtures thereof; and

the electron-withdrawing anion is selected from fluoride, chloride, bromide, phosphate, triflate, bisulfate, sulfate, or any combination thereof;

wherein the catalyst composition is substantially free of an organoaluminum compound having the formula:



wherein (X^5) is a hydrocarbyl having from 1 to about 20 carbon atoms;

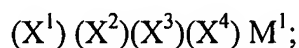
wherein (X^6) is a halide, hydride, or alkoxide; and

wherein n is a number from 1 to 3 inclusive; and

wherein the catalyst composition will produce a polyolefin when added to an olefin.

31. (previously presented) A process for polymerizing olefins in the presence of a catalyst composition, comprising contacting the catalyst composition with at least one type of olefin monomer, wherein the catalyst composition consists essentially of the contact product of:

a) a metallocene compound having the following formula:



wherein M^1 is selected from titanium, zirconium, hafnium, vanadium, niobium, tantalum, chromium, molybdenum, or tungsten;

(X^1) is selected from a Group-I ligand,

wherein the Group-I ligand is selected from a cyclopentadienyl, an indenyl, a fluorenyl, a substituted cyclopentadienyl, a substituted indenyl, or a substituted fluorenyl;

wherein each substituent on the substituted cyclopentadienyl, substituted indenyl, or substituted fluorenyl (X^1) is independently selected from an aliphatic group, an aromatic group, a cyclic group, a combination of aliphatic and cyclic groups, an oxygen group, a sulfur group, a nitrogen group, a phosphorus group, an arsenic group, a carbon group, a silicon group, a germanium group, a tin group, a lead group, a boron group, an aluminum group, $-SO_2X$, $-OAlX_2$, $-OSiX_3$, $-OPX_2$, $-SX$, $-OSO_2X$, $-AsX_2$, $-As(O)X_2$, or $-PX_2$, wherein X is selected independently from halide, H, NH_2 , OR, or SR, wherein R is

a hydrocarbyl, or a substituted derivative thereof, having from 1 to about 20 carbon atoms; a halide; or hydrogen;

(X³) is selected from an aliphatic group, an aromatic group, a cyclic group, a combination of aliphatic and cyclic groups, or a substituted derivative thereof, having from 1 to about 20 carbon atoms;

(X⁴) is independently selected from a Group-II ligand,

wherein the Group-II ligand is selected from an aliphatic group, an aromatic group, a cyclic group, a combination of aliphatic and cyclic groups, an oxygen group, a sulfur group, a nitrogen group, a phosphorus group, an arsenic group, a carbon group, a silicon group, a germanium group, a tin group, a lead group, a boron group, an aluminum group, -SO₂X, -OAlX₂, -OSiX₃, -OPX₂, -SX, -OSO₂X, -AsX₂, -As(O)X₂, or -PX₂, wherein X is selected independently from halide, H, NH₂, OR, or SR, wherein R is a hydrocarbyl, or a substituted derivative thereof, having from 1 to about 20 carbon atoms; a halide;

(X²) is independently selected from a Group-I or a Group-II ligand;

wherein (X¹) and (X²) are optionally connected by a bridging group, wherein the length of the bridging group between (X¹) and (X²) is one, two, or three atoms; the one, two, or one, two, or three atoms of the bridging group are independently selected from C, Si, Ge, or Sn; the bridging group is saturated or unsaturated; and the bridging group is substituted or unsubstituted; and

wherein any substituent on the bridging group is independently selected from an

alkenyl group, an alkynyl group, an alkadienyl group, an aliphatic group, an aromatic group, a cyclic group, a combination of aliphatic and cyclic groups, an oxygen group, a sulfur group, a nitrogen group, a phosphorus group, an arsenic group, a carbon group, a silicon group, a germanium group, a tin group, a lead group, a boron group, an aluminum group, $-\text{SO}_2\text{X}$, $-\text{OAlX}_2$, $-\text{OSiX}_3$, $-\text{OPX}_2$, $-\text{SX}$, $-\text{OSO}_2\text{X}$, $-\text{AsX}_2$, $-\text{As}(\text{O})\text{X}_2$, or $-\text{PX}_2$, wherein X is selected independently from halide, H, NH_2 , OR, or SR, wherein R is a hydrocarbyl, or a substituted derivative thereof, having from 1 to about 20 carbon atoms; a halide; or hydrogen;

b) the chemically-treated solid oxide comprises a solid oxide treated with an electron-withdrawing anion;

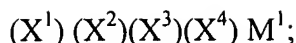
wherein the solid oxide is selected from silica, alumina, silica-alumina, silica-zirconia, alumina-zirconia, aluminum phosphate, heteropolytungstates, titania, magnesia, boria, zinc oxide, mixed oxides thereof, or mixtures thereof; and

the electron-withdrawing anion is selected from fluoride, chloride, bromide, phosphate, triflate, bisulfate, sulfate, or any combination thereof; and

wherein the catalyst composition will produce a polyolefin when added to an olefin.

32. (previously presented) A catalyst composition comprising the contact product of at least one metallocene compound, a cocatalyst, and at least one chemically-treated solid oxide, wherein:

a) the at least one metallocene compound having the following formula:



wherein M^1 is selected from titanium, zirconium, hafnium, vanadium, niobium, tantalum, chromium, molybdenum, or tungsten;

(X^1) is selected from a Group-I ligand,

wherein the Group-I ligand is selected from a cyclopentadienyl, an indenyl, a fluorenyl, a substituted cyclopentadienyl, a substituted indenyl, or a substituted fluorenyl;

wherein each substituent on the substituted cyclopentadienyl, substituted indenyl, or substituted fluorenyl (X^1) is independently selected from an aliphatic group, an aromatic group, a cyclic group, a combination of aliphatic and cyclic groups, an oxygen group, a sulfur group, a nitrogen group, a phosphorus group, an arsenic group, a carbon group, a silicon group, a germanium group, a tin group, a lead group, a boron group, an aluminum group, $-SO_2X$, $-OAlX_2$, $-OSiX_3$, $-OPX_2$, $-SX$, $-OSO_2X$, $-AsX_2$, $-As(O)X_2$, or $-PX_2$, wherein X is selected independently from halide, H, NH_2 , OR, or SR, wherein R is a hydrocarbyl, or a substituted derivative thereof, having from 1 to about 20 carbon atoms; a halide; or hydrogen;

(X^3) is selected from an aliphatic group, an aromatic group, a cyclic group, a combination of aliphatic and cyclic groups, or a substituted derivative thereof, having from 1 to about 20 carbon atoms;

(X^4) is independently selected from a Group-II ligand,

wherein the Group-II ligand is selected from an aliphatic group, an aromatic group, a cyclic group, a combination of aliphatic and cyclic groups, an oxygen group, a sulfur group, a nitrogen group, a phosphorus group, an arsenic group, a carbon group, a

silicon group, a germanium group, a tin group, a lead group, a boron group, an aluminum group, $-\text{SO}_2\text{X}$, $-\text{OAlX}_2$, $-\text{OSiX}_3$, $-\text{OPX}_2$, $-\text{SX}$, $-\text{OSO}_2\text{X}$, $-\text{AsX}_2$, $-\text{As}(\text{O})\text{X}_2$, or $-\text{PX}_2$, wherein X is selected independently from halide, H, NH_2 , OR, or SR, wherein R is a hydrocarbyl, or a substituted derivative thereof, having from 1 to about 20 carbon atoms; a halide;

(X^2) is independently selected from a Group-I or a Group-II ligand;

wherein (X^1) and (X^2) are optionally connected by a bridging group, wherein the length of the bridging group between (X^1) and (X^2) is one, two, or three atoms; the one, two, or one, two, or three atoms of the bridging group are independently selected from C, Si, Ge, or Sn; the bridging group is saturated or unsaturated; and the bridging group is substituted or unsubstituted; and

wherein any substituent on the bridging group is independently selected from an alkenyl group, an alkynyl group, an alkadienyl group, an aliphatic group, an aromatic group, a cyclic group, a combination of aliphatic and cyclic groups, an oxygen group, a sulfur group, a nitrogen group, a phosphorus group, an arsenic group, a carbon group, a silicon group, a germanium group, a tin group, a lead group, a boron group, an aluminum group, $-\text{SO}_2\text{X}$, $-\text{OAlX}_2$, $-\text{OSiX}_3$, $-\text{OPX}_2$, $-\text{SX}$, $-\text{OSO}_2\text{X}$, $-\text{AsX}_2$, $-\text{As}(\text{O})\text{X}_2$, or $-\text{PX}_2$, wherein X is selected independently from halide, H, NH_2 , OR, or SR, wherein R is a hydrocarbyl, or a substituted derivative thereof, having from 1 to about 20 carbon atoms; a halide; or hydrogen;

b) the cocatalyst is selected from an aluminoxane, an organozinc compound, an organoboron compound, an ionizing ionic compound, a clay material, or any combination

thereof; and

c) the at least one chemically-treated solid oxide comprises a solid oxide treated with an electron-withdrawing anion;

wherein the solid oxide is selected from silica, alumina, silica-alumina, silica-zirconia, alumina-zirconia, aluminum phosphate, heteropolytungstates, titania, magnesia, boria, zinc oxide, mixed oxides thereof, or mixtures thereof; and

the electron-withdrawing anion is selected from fluoride, chloride, bromide, phosphate, triflate, bisulfate, sulfate, or any combination thereof.